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Riparian Management Systems - An Introduction to RiMS

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Introduction

The areas along our streams, lakes, and rivers are an important part of the agricultural ecosystem. They work to mediate the influence of agriculture on our water resources. The general term for these areas is a riparian area. There is some debate as to the definition of a riparian area. One of the most common definitions from the Natural Resources Conservation Service (NRCS) is:

"Riparian areas are ecosystems that occur along watercourses or water bodies. They are distinctly different from the surrounding lands because of unique soil and vegetation characteristics that are strongly influenced by free or unbound water in the soil. Riparian ecosystems are a transitional area between terrestrial and aquatic ecosystems. Typical examples would include floodplains, stream banks, and lakeshores.

Indicators of riparian areas include:

1. Vegetation - The kinds and amounts of vegetation will reflect the influence of free or unbound water from an associated watercourse or water body and contrasts with terrestrial vegetation.

2. Soils - Soils in natural riparian areas consist of stratified sediments of varying textures that are subject to intermittent flooding or fluctuating water tables that may reach the surface. The duration of the soil wetness feature is dependent upon the seasonal meteorological characteristics of the adjacent water body.

3. Water - Riparian areas are directly influenced by water from a watercourse or water body. Riparian areas occur along natural watercourses such as perennial or intermittent streams and rivers, or adjacent to natural lakes. They may also occur along man-made watercourses or water bodies such as ditches, canals, ponds, and reservoirs.

A riparian management system can use many best management practices to create a "best possible option" for reducing negative impacts on water quality, erosion, organic matter loss, grazing and compaction, flooding, nutrient and chemical runoff, and invasive species.

To better understand the processes affected by RiMS, this module will identify some of the concerns within the agricultural landscape as well as RiMS parts that address those concerns. In the process, we will also identify some of the major programs that provide establishment incentives. Many of the examples in this module come directly from a riparian management system study being conducted by the Department of Natural Resources Ecology & Management at Iowa State University. The material presented in this paper is excerpted from the interactive courseware developed for the Crop Adviser Institute by Thomas Schultz and Richard Schultz of Iowa State University.

History of the landscape

As people settled in the Midwest, many landscape changes came about to improve productivity in the region. Some of these changes included: land clearing, tiling, wetland drainage, and channelization.

These changes in the physical shape and structure of the landscape affected many of the natural flows of energy through the system. Because of land clearing, tiling, wetland drainage, and channelization of streams, much of the hydrology has changed to produce:

- Increased and more surface and subsurface runoff
- More sediment loss & leaching
- Lower water tables

Inevitably, these changes have also affected the landscapes ability to mediate such things as flood events, soil loss and erosion, and water storage. As crop advisers and landscape managers, it is important to understand and view the landscape as a series of watersheds as well as a richly productive crop landscape.

Ecological Concerns

Surface runoff/infiltration

Growing crops in the Midwest has changed since the 1800's. Where we once used a team of horses and moldboard plow, we now use large tractors with the capability to plow hundreds of acres in a day. The use of these tractors has also influenced soil properties. Compaction is a major concern in fields because low soil permeability and massive soil structure create a landscape less suitable for seed germination and growth. Infiltration rates of these fields has dropped dramatically from their prior prairie infiltration rates. Where a field could once be expected to infiltrate 5-6 inches of water per hour in a heavy rainfall, many can now hardly support a 0.5 in/hr infiltration rate. This can cause field ponding, overland runoff, and erosion.

Organic Matter Loss

Organic matter in the soil is important for holding the soil together creating soil aggregates. The more organic matter there is in a soil, the better able that soil is to resist erosion and compaction. Aggregation in the soil is important because it provides high water holding capacity, aeration, drainage, and less compaction in the root zone of crops. The loss of organic matter that has been recorded in crop fields reduces aggregation and therefore reduces drainage, water holding capacity, and aeration.

Surface Runoff & Channel Evolution

Tiling has been an important part of improving crop productivity in the Midwest. All these tiles can, however, lead to increased erosion and a bypass of the soils "cleaning effect". In a single mile of stream, there can be as many as 10-20 tiles. These tiles bring water from the far reaches of the watershed by-passing the "living soil filter" and delivering water quickly to the stream increasing stream flow and channel erosion. The result is no cleaning of the water and high loads of sediment and agricultural chemicals entering streams.

Prior to European settlement, the pothole prairie landscape acted as a large sponge for rainfall holding it in wetlands and the deep prairie soils where plants transpired it back into the atmosphere. As a result, there were significantly fewer miles of stream channels. With the large scale changes in the landscape following settlement in the 1850's, surface runoff and subsurface tile flow created large volumes of water that eroded new channels and increased the size of existing ones.

Grazing and Compaction

Grazing in the riparian zone is a common occurrence because most other land that is easily cultivated by large farm equipment is used for growing crops. Cattle can compact the soil in the areas they walk, increase stream bank erosion, and directly foul the water when they loaf in the stream.

Flooding

Because of the modifications made to the landscape to grow large tracts of crops and improve drainage for crop growth, the Midwestern hydrologic system has become more flashy or faster draining. This makes a sizable difference when large rain events occur. Because fields have such a low infiltration rate now, much of the rain that falls on a field turns into runoff and takes chemicals and sediment with it. This all happens so quickly that the downstream areas cannot contain the elevated flow and creating flooding conditions.

Parts of a Riparian Management System

Riparian buffers and filter strips are similar in several ways including the ability to heal parts of the landscape in a short amount of time. Along with aesthetic improvements to the system, there can be drastic improvements to their biological and physical ability to reduce (clean-up, remove) non-point source pollutants.

Filter strips - Water quality improvement

Filter strips are an-all grass or prairie grass/forb option for filtering surface sediment and cleaning groundwater. Warm-season grass (WSG) species are typically better for filter strips than cool-season grasses. Some of these reasons are:

Warm-season grass roots grow deeper into the soil profile than cool-season grasses. Most cool-season roots don't grow much deeper than 18 inches while a WSG may grow down 3-4 feet depending upon the depth of the water table. Warm-season grass roots are typically much stronger than their cool-season counterparts and can hold soil better against the forces of erosion.

Warm season grass stems are tall and rigid which slow down water that runs through them rather than laying over and letting water run over them as do most cool-season grasses. By slowing the water as it enters the filter, much of the sediment is dropped in the crop field before entering the filter. Cool-season grasses are a great option where water is supposed to move quickly over protected soil such as a grassed waterway.

Riparian buffers/filter strips - Water quality improvement

Riparian forest buffers add a woody component between a grass filter and the stream. The filter provides effective surface trapping of sediment and provides an area of high infiltration for water to enter the soil. It them moves through the root zone of the woody plants where nutrients can be taken up and stored in the stems. Woody roots also provide additional strength to stream banks that may be eroding. Microbes under both the grass and woody zones can remove chemicals from the groundwater.

Geological site evaluations are imperative to estimate overall effectiveness of buffers. There can be large differences in residence time of groundwater between a coarse, sandy substrate and a dense, clay-fortified substrate. If the parent material below a buffer is coarse and sandy, groundwater may bypass riparian roots by going under a buffer. It is important to know what underground situation the land has so a riparian management system can be tailored to the site.

Plant and soil system nutrient removal

Plants are important to the agroecosystem in many ways. For instance plants provide friction to slow surface runoff and retain soil, take up and store excess nutrients that may otherwise reach the stream, and provide organic matter for improved soil structure and improved microbial activity.

Long-term N immobilization is greatest in woody community because woody biomass retains its integrity for long periods of time locking away N. Leaf litter and fine root turnover recycle carbon through a buffer in short periods of time. This also produces a pool of organic carbon that is important for microbial activity use in denitrification. Carbon pools available for denitrifying microbial communities are greater in buffers than in crop fields, and the microbial communities are able to immobilize more nutrients in the top foot of buffer soil than in a crop soil.

The plant/soil system is an effective sink if it has contact with soluble nutrients from uplands and denitrification potential is large in buffer soils increasing as a buffer ages.

Increasing above and below ground biomass is important to improve the C/N ratio in the soil and keep organic C available for use by microorganisms in denitrification.

Surface runoff/infiltration

RiMS can restore infiltration rates to 5X the speed of crop field/pasture sites. Large masses of woody and non-woody roots help to aerate and restore soil structure. At a research site in Story County, IA infiltration rates improved from 0.5 in/hr to 5-6 in/hr within the riparian zone of a restored buffer.

An 18 foot wide warm-season grass filters can remove more than 75% of sediment, and more than 40% of the total N & P, nitrate & phosphate in surface runoff. Adding a woody buffer component 33 feet wide to the warm-season grass filter further increases removal to more than 90% of sediment and more than 80% of nutrients in surface runoff.

Subsurface water flow

Nitrate is reduced in the soil because nitrogen fertilizer is not added this close to the stream and because of microbial denitrification and immobilization. Variable reductions in nitrate in the shallow groundwater are tied to nitrate loading and the supply of dissolved organic carbon which is needed by microbes for denitrification. Groundwater flow may take 30-90 days to move through a 66 foot wide buffer. Large variations in alluvial geology make prediction of buffer effectiveness difficult. Unfortunately, water from tile flow entering streams by-pass buffer system processes.

Stream bank Stabilization – bioengineering

In order to maintain working stream banks, you have to understand when it is effective to use stream bank stabilization and when other practices are more effective to accomplish conservation objectives. Vegetative stream bank stabilization is a wonderful tool to prevent more erosion and soil loss from occurring provided stream banks aren't at a 90 degree angle and banks can be sloped with at least a 1:3 slope then planted with material that will provide a net of woody roots.

Some advantages to vegetative stream bank stabilization are:

- Living root systems hold soil in place, increasing overall bank stability.
- Increased roughness directs flow velocity away from the stream bank and acts as a buffer against abrasive transported materials.
- Vegetation causes sediment deposition, reducing the stream sediment load and re-establishing the stream bank.

Debris dams are another way of intercepting loose soil before it enters a stream. These dams are created of living plant material that act as a sieve when placed in a gully, and slow water down enough to often times fill in that gully with sediment that was previously being lost.

Channel stabilization

Boulder weirs are in-stream grade-control structures that re-introduce riffles into streams that are often choked with sediment. These riffles do many things including:

- Provide aeration for invertebrates that fish feed on.
- Reduce water energy and speed and therefore erosion potential
- Water elevation is raised so stream banks are not quite as tall and therefore do not collapse as easily.
- Weirs can slow or stop channel downcutting so more stable channels can develop.

Tiles circumvent the living soil filter of the riparian by going underneath them. To improve water quality of the stream these tiles must also be dealt with. One way to improve tile water quality is to create wetlands at the tile outlets that intercept the flow before it enters the stream. The wetlands will trap sediment and remove nutrients from the water before it enters the stream. As a general rule of thumb, these wetlands should be sized 1 acre of wetland for every 100 acres of field drained.

By creating a wetland at a tile outlet, the water has a longer residence time in an environment where anerobic microbes can take much of the nitrate in the water and change it to nitrogen gas that makes up 70 % of the life-giving atmosphere we breathe. Where tiles cross below a buffer, special design considerations must be followed.

Rotational grazing

Grazing near a watercourse is often very hard on a stream. While cattle need access to a certain amount of water, they often "hang out" in the water adding to the nitrogen and phosphorous in the stream. Cattle also can compact stream banks and create erosion problems. Moving cattle into a rotational or lower impact grazing system can also improve water quality and stream bank stability. Cattle access to the stream itself should be limited to crossings or drinking areas. The rest of the stream should be fenced to limit access from the channel but not the rest of the riparian area. Just by this one step, stream banks and water quality can be greatly improved without further costly modifications.

Summary

Hydrology in the Midwestern landscape has been changed drastically during the last 150 years. Problems facing our watershed resources include: runoff and low infiltration rates, organic matter loss, grazing and compaction, and flooding.

Because of our need to grow crops on these fertile soils, efforts must be taken to conserve these soil resources. *Riparian Management Systems* can help to create a more productive and stable hydrological environment. Riparian management systems are only one part of a larger sustainability issue, and in order to provide a more sustainable landscape they should be used along with other upland best management practices.

For the entire interactive, computer-based version of this material please visit the Crop Adviser Institute on-line at www.cai.iastate.edu.

Web Links

Riparian Management Systems (Iowa State University) – http://www.buffer.forestry.iastate.edu
National Agroforestry Center (NAC) - http://www.unl.edu/nac/
NRCS conservation Programs - http://www.nrcs.usda.gov/programs/
Agroforestry Notes - http://waterhome.brc.tamus.edu/projects/afnote3.htm